Essays on the investment behaviour of danish farmers

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PhD thesis

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Essays on the Investment Behaviour of Danish Farmers

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Abstract

The overall aim of this thesis is to empirically investigate investment behaviour in Danish agriculture with a special focus on pig producers. Qualitative studies have questioned the "Economic man" model as the basis for research in the field. This thesis adopts a quantitative approach to investigate farmers' investment behaviour. The farmers' access to finance is investigated as this influences the attitude towards financial and business risk. Both financial and business risk are influenced by investments undertaken. Socioeconomic factors and self reported answers to investment incentives are investigated under two financial contexts to quantify the effects on investment behaviour. Finally is the investment utilisation investigated as the effect on the farm technical efficiency.

The thesis consists of an introduction and four manuscripts. Two manuscripts (II and III) are based on farm investment surveys which were sent to Danish farmers, whilst manuscripts I and IV are based on farm accounts from 1996 to 2009 (2008) retrieved from a national database. Manuscript I investigates the development in access to finance for e.g. investments and is based on 92,000 farm accounts from full-time farms during the period 1996 to 2009. The results indicate that access to finance eased during the period and accelerated from 2004 to 2009 which was when the farm debt capacity expanded the most. Farmers in Denmark have access to approximately twice the amount of external finance in 2008 compared to 1996, based on the same set of assets when controlling for inflation, age and farm income.

The objective of manuscript II is to analyse and empirically test investment behaviour. Both the effect of the incentives and socioeconomic factors in investment behaviour are analysed. The analyses are based on a farm survey of 208 pig producers. The analyses indicate that socioeconomic factors affect farm investment behaviour with larger farms and younger farmers being more inclined to make investments. Total investments are negatively related to equity. The manuscript further indicates that higher total equity and farm income and farmers with better partial productivity agree more with the incentives aimed at economic development in the short and long run, which suggests that a prerequisite for achieving good financial results is that this is also what drives the investments.

Manuscript III investigates whether expectations and incentives are context specific. The research is based on two farm surveys of Danish farmers' investment expectations and incentives in January 2008 and October 2009, which is before and after the start of the financial crisis. The expected investments were significantly lower for the land, pig units and machinery after the start of the financial crisis than prior to the crisis. When

summarising the incentive changes one can say that the farmer plans to optimise the long term profit and long term goals of the company when there is financial latitude. Conversely, when the financial situation deteriorates, the decision maker acts more short sightedly. Furthermore, the results suggest that the non-responders' investment incentives are less context dependent than the investors' incentives.

The objective of manuscript IV is to empirically investigate the size and timing of adjustment costs, as well as investment utilisation in Danish pig production. We derive a theoretical model for adjustment costs and investment utilisation and we estimate stochastic frontier output distance functions and measure the size and timing of adjustment costs jointly as the effect on technical efficiency. We analyse the effect of lagged investments on the farms' technical efficiencies and we derive the marginal effects of these variables on efficiency and develop a method for calculating the adjustment costs as foregone profit. We thoroughly discuss the calculation and deflation of capital and derive a new methodology for deflating capital. Investments have a negative effect on efficiency in the investment year and the year after. Two and three years after the investment, there is a positive effect on efficiency. From an efficiency perspective, the farmer should make investments when he is between 50 and 60 years of age. The farmers at the age of 49 have, *ceteris paribus*, the highest technical efficiency

Resumé (Danish Summary)

Formålet med PhD-afhandlingen er empirisk at analysere investeringsadfærden i dansk landbrug med særlig vægt på svineproducenterne. Kvalitative studier af investeringsadfærden har sat spørgsmål ved brugen af "Economic man"-modellen som grundlag for forskning indenfor området. Denne afhandling bidrager med en kvantitativ tilgang til at analysere investeringsadfærden for landbrugsinvesteringer. Landmændenes adgang til finansiering er undersøgt, da dette har indflydelse på tilbøjeligheden til at påtage sig finansielle risici og forretningsrisici. Både finansielle risici og forretningsrisici påvirkes af de foretagne investeringer. Socioøkonomiske faktorer og selvrapporterede svar på investeringsincitamenter er undersøgt under to finansielle paradigmer for at kvantificere effekterne på investeringsadfærden. Endelig er investeringsudnyttelsen undersøgt som effekten på den tekniske efficiens for bedrifterne.

Afhandlingen består af fire manuskripter. To manuskripter (II og III) er baseret på spørgeskema-undersøgelser foretaget blandt danske landmænd mens manuskripterne I og IV er baseret på årsrapporter fra perioden 1996 til 2009 (2008), som er trukket ud fra en national database. Manuskript I undersøger udviklingen i adgangen til kapital til f.eks. investeringer og er baseret på 92.000 årsrapporter for heltidsbedrifter i perioden 1996 til 2009. Resultaterne indikerer, at adgangen til kapital er blevet væsentlig nemmere i perioden 1996 til 2009. Den blev særlig udvidet i perioden 2004 til 2008, hvor låne "teknologien" blev udvidet mest. Danske landmænd har approksimativt adgang til dobbelt så meget kapital i 2008 i forhold til 1996 baseret på de samme aktiver, når der er kontrolleret for inflation, landmandens alder og indkomst fra landbruget.

Formålet med manuskript II er, at undersøge hvad der driver landmændenes investeringer. Herunder er både incitamenterne og de socioøkonomiske faktorer, som påvirker investeringsadfærden, undersøgt. Analyserne er baseret på 208 spørgeskemaer fra danske landmænd. Analyserne indikerer, at socioøkonomiske faktorer påvirker landmændenes investeringsadfærd, hvor landmænd med stor produktion og de yngre landmænd er mere tilbøjelige til at investere. Investeringsomfanget har en negativ sammenhæng med egenkapitalen på bedrifterne. Analyserne indikerer videre, at landmænd med højere indtægter fra landbruget samt landmænd med bedre partiel produktivitet er mere enige i incitamenterne vedrørende økonomisk udvikling af bedriften på både kort og lang sigt. Dette indikerer, at forudsætningen for at have gode økonomiske resultater er, at det også har været incitamentet til at foretage investeringen.

I manuskript III undersøges om forventningerne til investeringerne og incitamenterne er kontekstafhængige. Manuskriptet baserer sig på to spørgeskemaundersøgelser, som er sendt til danske landmænd i januar 2008 og oktober 2009, hvilket er før og efter starten af den finansielle krise. De forventede investeringer var signifikant lavere for både jord, stalde og maskiner efter den finansielle krises ikrafttræden i forhold til før krisen. Sammenfattende for investeringsincitamenterne er det, at når der er finansielt råderum til det søger landmændene at optimere den langsigtede profit og de langsigtede mål for virksomheden. Når situationen forværres, agerer beslutningstagerne mere kortsigtet. Derudover indikerer resultaterne, at landmænd, som ikke så ofte laver investeringer, er mindre kontekstafhængige end landmænd, der ofte laver investeringer.

Formålet med manuskript fire er empirisk at undersøge størrelsen og timingen af indkøringstabene og investeringsudnyttelsen i dansk svineproduktion. Vi udleder en teoretisk model for indkøringstab og investeringsudnyttelse og vi estimerer en Stochastic Frontier output afstandsfunktion og estimerer samtidigt størrelsen og varigheden af indkøringstabene som nedgangen i den tekniske efficiens. Vi analyserer effekterne af de laggede investeringer på bedrifternes tekniske efficiens og udleder de marginale effekter af disse variable på efficiensen. Indkøringstabene beregnes som den manglende indtjening for bedriften. Beregningen og deflateringen af kapitalinputtet bliver diskuteret indgående og vi udleder en ny metode til at deflatere kapital. Investeringerne har en negativ effekt på efficiensen i investeringsåret og i året derefter. To og tre år efter investeringerne er der en positiv effekt på efficiensen. Fra et efficiens-synspunkt skal landmændene foretage investeringerne når de er mellem 50 og 60 år gamle. Landmændene har alt andet lige den højeste tekniske efficiens når de er 49 år gamle.

Preface

I entered this Industrial PhD-study after two and a half years work experience and this PhD-study was an opportunity to ease my curiosity of the farm investment behaviour which I have encountered in my experience with Danish Farmers and their investments.

First of all I would like to thank the farmers who participated in the surveys and made the analyses possible and to the economic consultants in Danish Agricultural Advisory Service who participated in the expert monitoring group. My main supervisor Mogens Lund deserves a special thank because he made the PhD-study possible, for always prioritising the supervising meetings and for a good supervision in the study. I would like to thank my co-supervisors Stine Hjarnø Jørgensen, Johannes Raaballe, and Arne Henningsen for their contribution to fulfilment of this thesis and Torben Wiborg for hiring me and making the path at the Knowledge Centre for Agriculture.

I would like to thank The Knowledge Centre for Agriculture for giving me the opportunity and for giving me the room to focus on the project even though there are other tasks to be done. My thanks also go to all employees at the Knowledge Centre for Agriculture, Business Finance especially the Business Management department. My thanks also to Michael Friis Pedersen, co-author of paper one has been inspiring for me. Thanks also for the friendships of Aarhus University with Anders Ryom Villadsen, Jesper Rosenberg Hansen, and Rune Bysted.

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Jakob Vesterlund Olsen

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Introduction

The PhD thesis concerns the investment behaviour of Danish farmers. It was initiated at a time of accelerating farm land prices, but without an increase in the earnings to service the debt incurred by farm land investments. At the same time the access to finance was easy. One motivation to start the project was the perception of suboptimal resource allocation in the Danish agriculture, which could be caused by the easy access to finance. The opportunity to investigate the changes in incentives and investment expectations in a different financial context, as a consequence of the financial crisis, was pursued. The desire to understand the factors that influence farmers when undertaking investments in agriculture, led to this quantitative study of investment behaviour in Danish agriculture.

Research question

What are the drivers and impacts of farmers' investment behaviour in Denmark?

Subordinate objectives:

1. To investigate how access to finance has developed in recent years in Danish agriculture and to propose a relevant measure of the change in access to finance.
2. To investigate the impacts of socioeconomic factors and investment incentives on farmers' investment behaviour.
3. To investigate the impact of the financial context on investment expectations and investment incentives.
4. To investigate the impact of investments on efficiency and utilisation of farm investments.

The scope of the thesis

The four manuscripts included in the thesis are presented after the general introduction in the following order:

Manuscript 1: An Empirical Analysis of Access to Finance for Danish Farms: Understanding Investment and the Absence of Risk Management

Manuscript 2: The Impact of Socioeconomic Factors and Incentives on Farmers' Investment Behaviour

Manuscript 3: An Empirical Test of the Effects of Financial Context on Investment Incentives and Expectations

Manuscript 4: Investment Utilisation, Adjustment Costs, and Technical Efficiency in Danish Pig Farms

The aim of this introduction is to introduce the four manuscripts, which form the following chapters and to illustrate the relation between the manuscripts. There is a direct relationship between the above subordinate objectives and the manuscripts such that manuscript I is concerned with the first objective and so forth. Manuscript I frames the context in which Danish farmers have made their investment decisions. The implications of a growing supply of liquidity and an environment in which more and more farmers were investing caused a paradigm in which high farm investment frequency was more the norm than the exception. Investments in land in the 1990s and 2000s led to an increased debt load, but also to increasing equity. We argue that investment and risk management behaviour have been affected by the access to finance as also argued in the Risk Balancing concept of Gabriel and Baker (1980). The developed measure of access to finance shows that the period from 1996 and especially from 2003 to 2008 has been characterised by increasing access to finance.

The focus of manuscript II is to quantitatively investigate the socioeconomic factors influence on investment incentives and investment behaviour to gain knowledge of the factors which influence the farmer when undertaking investments. Manuscript I frames the context for manuscript II and III as it describes the macroeconomic investment climate external to the farm. The degree of access to finance as measured in manuscript I is a macroeconomic factor which is external to the farm. Manuscript III is an extension to manuscript II, as the statements on investment incentives and investment expectations were replicated in another financial context. The investigation concerns the changes in incentives and investment expectations; the investment expectation summarises the financial and psychological context which had changed between the two questionnaires. If the context and expectations are lucrative in terms of access to finance, price expectations, and equity development and other external factors, then the investment expectations are high. If the incentives and expectations are framed in an adverse financial context then the responses were expected to change accordingly. Manuscript IV is also concerned with the drivers of investments. The real investments are often highlighted as having a role in securing a competitive firm (Hart & Lence, 2004). Manuscript IV analyses whether the real net investments in agriculture have an effect on farm efficiency. The investments are increasing capital costs and farm production. However, the value of the added farm production should more than offset the higher capital costs if competitiveness is to be increased. Special emphasis is made on the measurement of capital. Overall, the four manuscripts are concerned with factors, which could have an effect on investment behaviour, from access to finance, via economic and non-economic incentives measured in two financial contexts to the increased competitiveness.

The drivers of investments can be divided into two groups, which we call external explanations and internal explanations. The external explanations are factors common to all decision makers in the sector such as prices, legislation, access to external finance etc. The internal explanations are socioeconomic factors and

(non-economic) incentives, which vary from one decision-maker to another. Qualitative studies have been made of the internal factors affecting investment behaviour in agriculture (Jacobsen, 1994), which this study complements by a quantitative approach.

Investment behaviour is by its very nature a psychological phenomenon and this has been acknowledged by restricting the theoretical assumptions to a minimum. This is in line with the growing literature on behavioural economics (Camerer *et al*., 2004; Tversky & Kahneman, 1986) and behavioural finance (Thaler, 1993). Models have been chosen so that omniscient rational behaviour is not imposed on the decisions, e.g. no specific utility functions have been suggested because this simplification of real behaviour has been rejected with the introduction of reference dependence and loss aversion (Tversky & Kahneman, 1991; Simon, 1986).

Research field

A comprehensive study of investment behaviour in agriculture was made by Brase and LaDue (1989), although this primarily utilised aggregate investment models. Investment behaviour has been investigated within a decision theoretical framework by Jacobsen (1994) and Öhlmér (1997) and (Öhlmér *et al.*, 1998) and with more quantitatively based approach made by Hegrenes *et al.* (1991). Equipment investments have been studied by Jacobsen (1996) who concluded that the accelerator and neoclassical investment models were not descriptive of the actual farm-level investment behaviour.

Johnson *et al*. (1961) were the first to investigate the managerial process of decision-making in agriculture, whilst they also investigated the expectation formation and economic model building of farmers. Partenheimer and Bell (1961) (in Johnson *et al*. 1961) identified five areas in which expectations are required to make a decision, including price and market conditions and the production response to these conditions. The expectation formation is dependent on the age and experience of the farmer and the years of formal schooling. Jacobsen (1994) investigated the decision-making process of Danish farmers in the short, medium, and long term. He concluded that future research should consider actual decision-making in farm management and he questioned the assumptions of the "Economic man" model as the basis for research in the field. Jacobsen (1994) emphasised that future research needs to be better at describing the actual behaviour of decision-makers than the present normative decision models. Hegrenes *et al*. (1991) surveyed investment models and concluded that no general conclusions could be drawn regarding what governs farm investments. Hegrenes *et al.* (1991) found that the decision to invest is based on attitude, personality and comfort, as much as it is based on financial conditions. Öhlmér *et al.* (1998) included more steps in the decision-making process when investigating Swedish farmers' decision-making process, which is in line with the research of Jacobsen (1994).

Farming can be seen as a lifestyle as well as a job. Most often the farmer lives on the farm with his family and with the firm organised as a proprietorship. The goal of the farmer interacts with the goals of the farm family. According to Gasson *et al.* (1988) and Jacobsen (1990), the goal of the farmer is not only to maximise wealth, but also to "Be your own boss", "Reach a satisfactory level of income", and "avoid having to sell," which illustrates the multi-faceted nature of farmer goals. Incentives for making investments in real assets beyond profit and/or wealth maximisation have not been quantitatively investigated. The investment decision may be seen as a parallel to household economics models (Singh *et al.*, 1986). In these models, utility is derived from consumption of own goods, or from the consumption of market goods whereby income is generated from selling the goods. The decision to consume or sell the produced goods is balanced to reach the highest utility. An investment decision can either involve investing to generate the highest possible pecuniary outcome, which is used to buy market goods, or investing in an asset which is associated with special attributes or amenities which generate on the job utility, but which lowers the disposable income available to buy market goods.

The majority of studies concerning investment behaviour from a behavioural approach are made within financial investments (Stracca, 2004) and within the analyses of mergers and acquisitions (Malmendier & Tate, 2005). Some of the results from these studies can be adapted within real agricultural investment behaviour. It is primarily the results which are independent of organisation such as "house money" (Thaler & Johnson, 1990), "mental accounting" (Thaler, 1999), "loss aversion" (Tversky & Kahneman, 1991), "herding" (Scharfstein & Stein, 1990; Graham, 1999) or other behavioural biases (Barberis & Thaler, 2003) which affect the investment decision.

Studies on investment behaviour based on neoclassical investment theory, Euler equations and q-models are frequent in agriculture (Hubbard & Kashyap, 1992; Benjamin & Phimister, 1997; Hüttel *et al.*, 2010). Gardebroek and Oude Lansink (2004) and Pietola and Myers (2000) used dynamic optimisation to measure the adjustment costs and optimal investment decisions. Their treatment of uncertainty and intertemporal effects are elegant and in line with the dynamic optimisation approach developed by Dixit and Pindyck (1994). These models are implicitly based on rational expectations, which assume that agents in the market adopt the same economic model as economists (Schiller, 1990). Schiller (1990) argues that the agents' and the economists' models are not identical, which renders models based on economists' models unable to describe and predict the actual behaviour of the agents in the market.

The influence of risk on investment behaviour is introduced through the risk balancing concept of Gabriel and Baker (1980). Risk and uncertainty are broad concepts and the construction of a good measure of risk,

which contains quantitatively determined risk measures and risk perceptions, is not pursued in this thesis. Risk is treated as other incentives related to investments in the survey.

The use of stochastic frontier models to investigate the properties of an industry has become widespread (Newman & Matthews, 2007; Sipiläinen, 2007). The most recent Danish contribution is Rasmussen (2010). Our contribution in manuscript IV is to analyse the effect of investments on farm efficiency in panel data. By doing that we contribute to the adjustment cost literature form a different perspective, than other studies of adjustment costs (Jorgenson, 1972; Lundgren & Sjöström, 2001; Pietola & Myers, 2000). Guan *et al.* (2009) used a frontier method to estimate the excess capital employed in Dutch agriculture and Blancard *et al.* (2006) used a frontier method to estimate the cost of being financially constrained. Financial constraints have been investigated intensively, especially in the developing economics literature.

Materials and method

The data used in the thesis are taken from two different sources; an accounts database and two surveys. A database containing farm accounts from the period 1996 to 2009 is located at the Knowledge Centre for Agriculture. The database has been used in the two manuscripts, "An Empirical Analysis of Access to Finance for Danish Farms: Understanding Investment and the Absence of Risk Management" and "Investment Utilisation, Adjustment Costs, and Technical Efficiency in Danish Pig Farms" which are presented as manuscript I and IV. The number of full-time farm accounts in the database ranges from 3,000 to 10,500 in the 14 year period. The farms are not representatively chosen. If the quality standards are met and the farmer gives his consent, then the account is transferred to the database. The part-time farmers in the database are not used, as it is assumed that a large part of these make investments to fulfil private goals. The other data source is surveys sent to pig producers in Denmark in January 2008 and October 2009. The pig industry was chosen as it is a rather large industry in Denmark and because no upcoming deregulation of prices or production rights was underway as was the case in the dairy industry. The comprehensive description of the empirical data with some descriptive statistics can be seen in Olsen (2008b) and documentation of the first survey is published in Olsen (2008a).

The ratio of pork prices to feed prices was unusually low in January 2008 because the price of feed, i.e. primarily grain, had increased rapidly in the autumn of 2007. The low pork to feed price was expected to end shortly thereafter, which explains why the appetite for investments was virtually unaffected by the poor price relationship. However, in October of 2009, there was a perceived effect of the crisis. The analysis of the effect of the crisis on the expectations and incentives is presented in manuscript III: "An Empirical Test of the Effects of Financial Context on Investment Incentives and Expectations".

Manuscript I: An Empirical Analysis of Access to Finance for Danish Farms: Understanding Investment and the Absence of Risk Management

This manuscript is co-authored with Michael Friis Pedersen and investigates the development in access to finance. Access to finance is suggested to have an impact on the level of financial and business risk in the risk balancing concept of Gabriel and Baker (1980). At a given level of access to finance is the level of business and financial risk balanced. If the perceived access to finance increases the farmer is expected to be willing to increase the financial or business risk. This can happen by undertaking investments or by altering the risk management procedures to obtain a new balance. A new way of measuring access to finance is developed and used on farm accounts from the period 1996 to 2009. The measure does not measure whether the farms are constrained or unconstrained but measures whether the access to finance has eased or tightened in the period. Furthermore, the measure does not rely on book valuation of assets, as they can be biased. The results show that the access to finance in the period eased considerably and this context constitutes the investment climate in which the following analyses were undertaken.

The analysis is based on 92,000 farm accounts from full-time farms during the period 1996 to 2009. The idea is to identify the change in access to finance for Danish farmers in the 14 year period. The investments in Danish agriculture in the analysed period are perceived to be driven by price increases of farm land. Valuation of the assets by the financial institutions is based on the commercial value of the farms, which implies that the equity of the farmers increases with increasing farm land prices. This is why our model primarily includes collateral as input in the model to determine the maximum debt. The employed method is Data Envelopment Analysis (DEA), which was first developed by Charnes *et al.* (1978). DEA is a non-parametric method to evaluate the relative performance in transforming inputs to outputs. The method is used within a new research area, which has been dominated by parametric methods. The change in the DEA efficiency score is calculated by use of a Malmquist productivity index, which is further decomposed making it suitable for measuring the debt capacity of the single farmer and the utilisation of the debt capacity. The debt capacity is approximated by the "best practice" frontier interpreted as the maximum debt which the farmer can reach, based on a set of assets and controlling for earnings before interest, taxes (EBIT) and operator age. Bootstrap techniques are used to resample the frontier in the model to account for the statistical significance of the proposed measure.

The analysis is made for each for the three dominant agricultural sub-sectors in Denmark, crop, dairy, and pig producers. The results show that the debt capacity for the three production types has developed similarly in the period 1996 to 2009. The results indicate that the access to finance eased in the period, but accelerated from 2004 to 2008 when the debt possibility expanded the most. Farmers in Denmark have access to roughly double the amount of debt in 2008 compared to 1996, based on the same set of assets when controlling for

inflation, age and farm income. The method allows for an implementation of e.g. the difference in the change of access to finance with respect to age levels or geographical regions.

Manuscript II: The Impact of Incentives and Socioeconomic Factors on Farmers' Investment Behaviour

The analysis of the factors influencing farmers when undertaking investments is a joint analysis with Mogens Lund. The paper builds upon previous Scandinavian research on investment behaviour where the decision to make the investment is the central aspect to investigate. Behavioural aspects are considered in a quantitative approach. Observed socioeconomic factors are related to investment incentives and to investment behaviour.

A link to an internet survey was e-mailed/mailed to a stratified sample of 398 full-time Danish pig producers. All the non-responders were contacted two weeks after the survey and those who did not have access to the Internet received a paper version of the survey. 208 farmers are included in the analysis. This manuscript analyses the investments completed in the period 2003 to 2006, the expected investments for the next three years, and the incentives to make investments. The incentives were subdivided into investments in land, pig units or machinery. The farm accounts were taken from the farm accounts database.

Logistic regression was used to analyse the effects of the incentives on investment behaviour, as this is considered to be a robust method to deal with ordinal-scaled variables. The proxy for investment behaviour is whether the farmers have invested in the past, plan to invest in the next three years, or haven't invested nor plan to do so. Also, the effects of socioeconomic factors on investment behaviour are analysed with logistic regression. Total investments are positively related to the size of the farm. There is a tendency for the off-farm income to be positively related to investments. Total investments are negatively related to the equity and age of the farmer. This is essentially parallel to Hennessy and O'Brien (2008) and LaDue *et al*., (1991) who also found size, age and farm income to be related to investments.

Socioeconomic factors' influence on the investment incentives is also investigated. The analyses indicate that higher total equity and farm income and farmers with better partial productivity agree more to the incentives aimed at economic development in the short and long run. It suggests that the farmers who have the best financial results are those who emphasise the economic incentives the most when making investments. This is not as intuitive as it might seem because the survey was performed during a period with substantial price increases in land. That is, the farmers who invested in land at the beginning of the decade are among the farmers with the highest equity, even if the land investment did not yield high accounting returns.

Manuscript III: An Empirical Test of the Effects of Financial Context on Investment Incentives and Expectations

The financial crisis in 2008 changed the financial context and caused the investments in Danish agriculture to decrease. Thus, the objective was to investigate whether the expectations and incentives are context specific (Einhorn & Hogarth, 1981). This analysis builds upon manuscript II as the financial context changed after the questions from the survey in manuscript II was gathered. The effect of changing financial context on investment expectations and incentives is investigated with the same set of questions as in manuscript III. It is believed, that it is important to know the incentives to make investments to forecast and advice on investments especially for the sole proprietorships, as they are not necessarily only governed by maximization of the wealth of the firm (Jensen & Meckling, 1976).

The intention was to investigate the changes without a potential bias of farmers who perceived them as being financially constrained (if I cannot borrow money I do not want to invest). Some farmers supposedly suffered from financial constraints at the time of the survey. However, it is necessary to present the statements as close to the original semantics as possible, as they need to be compared. The statements from the first survey about expected future investments (within three years) and the incentives to make investments were sent to the farmers who had completed the first survey. Of these, 146 farmers completed the survey which in the second round gave a response rate of 62 per cent.

A paired t-test was used to test whether the two samples represented the same population. Biased answers with regard to liquidity constraints are possible, as the liquidity supply changed from the survey in 2008 to the survey in 2009. If this is the case, it is expected that the farmers with lower farm income and lower equity would give more biased answers than others. The measure of access to finance from manuscript I was used to distinguish between farmers who are more credit constrained and less constrained. A t-test was used to test whether there is a difference between the two groups. Changes in incentives were analysed with McNemar's test and with Wilcoxon Signed Rank, as these complement each other and they are both suited to test ordinal scale variables.

Farmers' expected investments are significantly influenced by the financial crisis. The empirical analysis shows that the expected investments in all investigated asset types decreased from 2008 to 2009. Also, farmers' investment incentives changed as a consequence of the financial crisis. Farmers are less inclined to invest in land in order to enhance environmental performance, or to secure future investment possibilities after the beginning of the financial crisis. This is interpreted as risk mitigating behaviour, as land investments usually reduce available liquidity. The empirical findings show that when the financial context is prosperous, more farmers envision expansion, but such plans are suspended when conditions deteriorate.

Manuscript IV: Investment Utilisation, Adjustment Costs, and Technical Efficiency in Danish Pig Farms

This manuscript is co-authored with Arne Henningsen and its objective is to empirically investigate the size and timing of adjustment costs, as well as investment utilisation in Danish pig production. Adjustment costs have been investigated intensively in the literature. The analyses have often focused on the adjustment cost function and the dependence on the level of investment and the existing capital stock. The functional form of the adjustment cost function is important to determine the optimal investment level in the neoclassical investment theory. Individual farm level adjustment costs have been investigated in Dutch pig production (Gardebroek & Oude Lansink, 2004) determined on the basis of the investment decision. Our approach is different as we investigate the adjustment costs on the basis of the individual effect on the farm technical efficiency hence the adjustment costs and investment utilisation are investigated *per se*.

We derive a theoretical model for adjustment costs and investment utilisation and we estimate a stochastic frontier output distance function and measure the size and timing of adjustment costs jointly as the effect on technical efficiency. We analyse the effect of lagged investments on the farms' technical efficiencies, where we allow for interaction effects between lagged investments and other variables, such as farm size and the farmer's age. Finally, we derive the marginal effects of these variables on efficiency and develop a method for calculating the adjustment costs as foregone profit. Given the importance of measuring capital input correctly, we thoroughly discuss the calculation and deflation of capital and derive a new methodology for deflating capital.

The dataset used in the estimation is the full-time pig producers from the accounts database at the Knowledge Centre for Agriculture. The dataset is an unbalanced dataset from which 9,281 observations are used in the estimation. Each farm was in the dataset for at least 4 consecutive years.

The results show that investments in farm assets have a positive effect on farm efficiency for two to three years after the investment, which more than offsets the adjustments costs in the year of the investment and the year after. The marginal effect of investments in year t (year of efficiency analysis) is negative, where the estimated effects of investments made in year $t-2$ and $t-3$ are positive. The optimal age of the farmer, in terms of investment, is in the 50ies, which implies that middle-aged farmers and larger farms are better at utilising their investments. The farmers aged 49 have, *ceteris paribus*, the highest technical efficiency.

Comprehensive discussion

On the basis of the analyses in this thesis, I argue that socioeconomic and non-pecuniary elements matter when it comes to investment behaviour and this should be taken into consideration when evaluating farmers' investment plans. Investments for proprietorships are special because the firm is often owner-managed, which results in another balance between financial and non-financial returns from the investments. In the investor-owned firm, the balancing is performed on the basis of the return from investing in non-pecuniary elements, such as better than necessary staff locations, fringe benefits and other employee preserving measures. The owner-manager may balance the pecuniary and non-pecuniary elements so that he/she equates the utility of higher after tax income with the utility from non-pecuniary elements. The data from the first survey did not reveal any direct effect of the incentives on the investment behaviour for which there could be multiple reasons, e.g. the limited variance in the responses to the statements. This reduces the chance of determining an effect. Some responders could have a cognitive dissonance whereby the response diverges from their true behaviour because some incentives are perceived as being more legitimate than others. Despite the unevenly distributed responses, socioeconomic factors were found to have an effect on the investment incentives.

A contribution of this thesis is the proposed measure of the change in access to finance. This quantitative measure contributes to the large field of agricultural finance and investment. The measure can be used to investigate the effect of access to finance on the structural development in sectors with many homogenous firms. The measure can be employed to investigate whether firms with certain characteristics have had an easier access to finance compared to other firms. It could perhaps be used to monitoring the total lending to farmers or other industries. If the credit models changes in the future, the measure can be altered to fit other credit scoring models. It is expected that cash flows are emphasised more in future agricultural credit models. This can be implemented in the model and the input slack in the model can be used to indicate the constraining factor of one borrower compared to the frontier.

The incentives for farm investments are influenced by the financial context, which can be seen in manuscript III in which the incentives for the farmers changed from January 2008 to October 2009. The results suggest that the financial context affects some farmers, but not others. The non-investors, which are less affected by the financial context, are older and have smaller farms than the investors who are more affected by the context. It is difficult to distinguish between the potential effect of cognitive dissonance and context on investors.

The investment utilisation of net farm real investments has been investigated, which revealed an increase in farm efficiency after a period with a negative effect on the farm efficiency as a consequence of adjustment

costs. This is not equivalent to saying that it is a profitable investment, but that the investments contribute to improved efficiency in transforming inputs to outputs on the farm.

The overall contribution of this research is apparent when viewing the thesis as a whole in that it comprehensively analyses investment behaviour covering the influence of finance on investments, pecuniary returns, non-pecuniary returns and the increased farm efficiency as drivers of the investment behaviour of Danish farmers.

Conclusion and further perspectives

During the period 2004 to 2008, access to external finance eased considerably whilst at the same time investments increased in Danish agriculture. These effects are believed to be mutually dependent in that an increase in access to finance motivates farmers to assess higher business- and financial risks. This occurred at a time when there was no observable increase in profitability, especially not in pig production.

The incentives at any given time may change if the financial context changes and the underlying assumptions change with them. The thesis provides new knowledge, based on quantitative methods, to supplement the advisors' subjective knowledge, based on personal perceptions and experience, which can be used to improve investment advice to farmers. The quantitatively analysed investment behaviour can be utilised in targeted advice about investment, strategy etc. when farm goals are important.

Farm advisors should carefully evaluate whether incentives for investment other than economic are present, and together with the farmer, evaluate whether these incentives are also fulfilled under an adverse financial context. Farm investment advice might be based on scenario analyses, instead of the more traditional sensitivity analysis in which only a few parameters are changed simultaneously thereby failing to replicate a true shift in the financial context. Also, advice to farmers might be altered to include not only normative decision rules, but also knowledge about behavioural biases from the past, as this seems to have been important for farmers. The effects of non-pecuniary factors on investments could be influential when making investments. More enlightened investment decisions would be undertaken if the net effects of not undertaking the wealth maximising investments could be estimated. Non-economic incentives for making investments are important to examine and it is important to quantify the costs of pursuing the non-economic goals to have a decision-making process not guided by feelings. It is, however, important to incorporate these with caution, as the incentives can change with the financial context.

Future research in investment behaviour should emphasise the contextual nature of investment as this is important for decision-makers. Knowledge about actual investment behaviour cannot be used as a guideline for farm investment, or to predict how investments should be performed. The knowledge of actual behaviour should be used to highlight the differences between the value maximising investment behaviour and the preferred investment behaviour.

A latent variable construction of the incentives for making investments whereby personal characteristics and risk perceptions are included in a structural equation model could be a guide for further research. In corporate finance, there are examples of research in which elements other than investment opportunities and expected returns govern the investments. Stein (2003) and Jensen (1986) report an empire building bias whereby managers overinvest when free cash flow relative to investment opportunities is higher than expected. Another bias is overconfidence (Malmendier & Tate, 2005) in that the more confident CEOs are found to engage in more value destroying mergers and acquisitions than their not so overconfident counterparts. To my knowledge, no such analyses have been conducted on proprietorships, which are characterised by owner managers and therefore do not have a board to convince when investing. In times of increasing access to finance, it does not seem as if it has been difficult to convince the banks to lend money to invest.

There are no apparent agency costs when the owner and the manager is the same person. However, owner managed firms may possibly suffer from behavioural biases. If the owner manager is modelled as man with two sets of preferences, as in Thaler and Sefrin (1981), whereby the one set represents the owner and the other represents the manager, then the owner may be more interested in pecuniary returns than the manager, even though they are one and the same person.

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